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OSTEOARTHRITIS IN FOSSIL MARSUPIAL POPULATIONS OF AUSTRALIA

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ABSTRACT

The Australian Pleistocene marsupial population, as represented in the fossil record, demonstrates a limited distribution (affecting only two skeletal sites) but high frequency of osteoarthritis. Other forms of articular disease were notable by their absence. Osteoarthritis was noted in the proximal portion of the fourth metatarsal in macropods, and the astragalus in *Diprotodon* (both weight-stress bearing sites). The population frequency of osteoarthritis in weight-stress bearing regions in marsupials is similar to that in man.

INTRODUCTION

The taxonomy, distribution, and osteology of extinct Australian Pleistocene marsupials has been a subject of great interest (Raven and Gregory, 1946; Tedford, 1966). Previous studies of paleopathology have concentrated on man (Harcourt, 1971). Therefore, little is known about the history of non-human diseases, especially in Australian animals. Whereas isolated examples of pathology have been described, predominantly in captive animals, Horton and Samuel (1978) note the absence of previous population analyses. Attempts at population analysis have been limited to infectious disorders. Horton and Samuel (1978) reported a study of 2700 bones belonging to the kangaroo *Macropus titan,* dated at 26,600 ± 650 years before present. Examination of the descriptions and photographs of the pathologic specimens in that survey indicated that all identified lesions were infectious. Erosions, periosteal reactions, and other signs of osteomyelitis (bone destruction and/or new bone formation) and infectious arthritis were noted involving a fourth and fifth metatarsal, a metatarsal-tarsal joint, one femur, and two tibiae. With the exception of one possible example of osteoarthritis involving a fifth metatarsal, no credible osteoarthritis was noted. The specimen was described (Horton and Samuel, 1978:284) without illustration, as having "osteophytes surrounding the proximal articular surface and along the proximal third of the dorsal edge of the bone." This represented one of 55 metatarsals, for a population frequency of 1.8%. That example, however, was companion to a clearly infected fourth metatarsal, so the diagnosis of osteoarthritis must be considered unconfirmed.

Examination of isolated elements of available Pleistocene fauna in the collections of the Australian Museum, Sydney, and the Queensland Museum, Brisbane, revealed minimal pathology, with the exception of two groups for which sufficient numbers were available for population analysis. A combined 294 macropods

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(kangaroos) and 19 *Diprotodon* (an ox-like marsupial noted for its two forward projecting teeth), were available from the Sydney and Brisbane collections for definitive analysis of the frequency of bone pathology.

Methods

Postcranial skeletons of macropods and *Diprotodon* in the collections of the Australian Museum and the Queensland Museum were examined for evidence of pathology. These collections represented disarticulated finds grouped by bone, since association by individual was not possible at the time.

Although it is known that the materials were collected during the nineteenth century from the Wellington Caves, Bingara, and Darling Downs, other than their Pleistocene age, all specifics with respect to site description and stratigraphy have been lost. The specimens are currently grouped according to bone, without attempt at identification below either the family Macropodidae or the genus *Diprotodon.* In the absence of any recent (i.e. twentieth-century) review of *Diprotodon,* no specific assignments can be confidently made.

Results

The postcranial skeletons of 294 Pleistocene macropod fossils were examined for evidence of pathology. No alterations compatible with infection were identified in any of the post-cranial bones. Osteoarthritis, as manifested by osteophyte formation (bony overgrowth), was limited in distribution to the proximal articular margin of the fourth metatarsal. Pathology was notable by its absence from any other post-cranial bone. No evidence of eburnation (polished appearance secondary to grinding) could be identified. Osteophytes were noted in 78 of 294 fourth metatarsals examined (Fig. 1a). Radiologic examination for evidence of subchondral sclerosis (complication of osteoarthritis related to microfractures and healing) proved unrewarding, as density was uniform. Longitudinal section of a metatarsal revealed the ivory-like nature of the proximal portion of the fourth metatarsal (Fig. 1b). It should be noted that the fourth metatarsal is the weight- and shock-bearing bone involved in jumping. Though the affected metatarsals were not identified to species, all represented adult animals. Approximately one-third of the metatarsals were from individuals the size of giant kangaroos and so may well have represented *Macropus titan.* When bones were grouped by size, however, the frequency of osteoarthritis of the proximal fourth metatarsal was uniform and independent of size.

Examination of *Diprotodon* postcranial elements revealed only one pathologic specimen compatible with infection. Minimal subchondral erosive disease was noted in the astragalus. Sectioning the specimen through the erosion revealed a picture (thick reactive new bone formation) compatible with infection. Examination of the available bones representing the skeletons of 19 individuals revealed osteophyte formation involving the proximal portion of one tibia, the distal portion of one humerus, and five astragalar bones. As was noted for macropods, eburnation was notable by its absence. Radiologic examination proved unrewarding for identification of subchondral sclerosis.

Discussion

Osteoarthritis is the most common form of bone-joint pathology affecting man (Rothschild, 1982; Engle et al., 1968). It presents as destruction and loss of articular cartilage, and is associated with remodeling of the subchondral bone (Rothschild, 1982). This remodeling basically takes three forms: 1) remodeling of the external surface of the bone results in overgrowth or osteophyte formation; 2) remodeling of the internal surface of the bone results in condensation and sclerosis of the

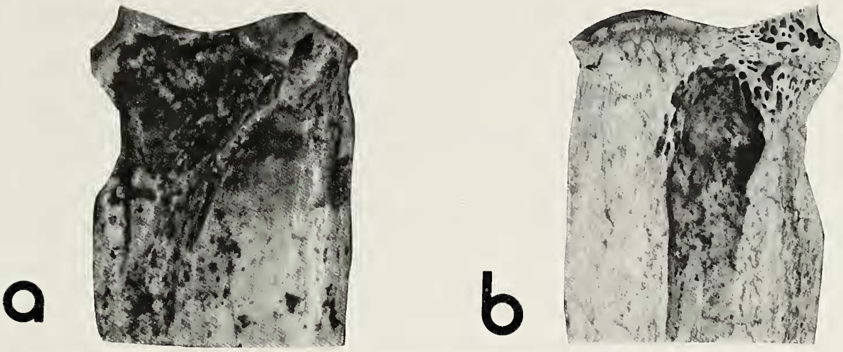

Fig. 1a.—Lateral view of proximal portion of fourth macropod metatarsal. Osteophytic spurring is noted as bony overgrowth at border of articular surface. 1b. Cross section of specimen illustrated in Fig. 1a. Osteophytic spurring is associated with a generalized ivory-like appearance of the bone.

underlying bone; and 3) occasional cyst formation in areas of relatively weakened bone. The ivory-like bone, noted above in the marsupial specimens examined, precluded cyst formation or sclerosis of the bone underlying the cartilagenous surface. The only recognizable manifestations of osteoarthritis in these marsupials would be osteophyte formation, which was observed only in select sites.

This study represents the first concerted analysis of arthritis in free-ranging marsupials, living or extinct. Bias inherent in sample selection must be regarded as minimal, as the entire population in the collections was examined. How representative of the endemic population is the population of specimens in the Sydney and Brisbane collections? As the collection logs and specimen descriptions are no longer available, this question is difficult to answer. It is, however, likely that the collected specimens represent the totality of excavation at the sites and, therefore, are representative of the bone bed in which they were found. Secondly, the osteoarthritis present is unlikely to be directly related to the animals' demise. Therefore, the collections probably do not reflect a population sampling selected on the basis of disease and can probably be considered representative of the endemic population.

Osteoarthritis was present in 27% of fossil Pleistocene kangaroos, independent of classification to species, but limited in distribution to the fourth metatarsal. The fourth metatarsal is the weight- and shock-bearing element of the lower extremity. Its ivory-like density appears to be a modification for facilitation of its handling of such stresses. The osteophytes probably affected the kangaroos only minimally, if at all, in their ability to function. Extent of osteophyte formation and clinical symptoms in man correlate only imprecisely. Thus it is impossible to be certain that these fossil kangaroos were in any way limited during life by their osteophyte development.

The unusual cranial appearance of *Diprotodon* is matched by that of its feet. The wrist joint is, at least in part, a ball-and-socket joint, the distal radius terminating in an articulating ball. The ball-and-socket forefoot may have offered relative protection from the occurrence of osteoarthritis, as forelimb involvement was demonstrable only in one distal humerus. The pronated posture of the rear foot, with the animal essentially walking on the side of its foot in a manner analogous to that of the giant ground sloth *Paramylodon,* may have been predisposed to astragalar involvement. The astragalus may represent the primary weightor stress-bearing site in *Diprotodon* and the osteoarthritis predominantly presenting at that site is as would be anticipated.

The disarticulated nature of the collection precludes age assessment beyond maturity, as age in marsupials is typically determined by teeth and their wear patterns. Osteoarthritis was common in Pleistocene macropods and *Diprotodon,* predominantly involving those joints which were at mechanical disadvantage. The 27% frequency of osteoarthritis in macropods and 26% frequency in *Diprotodon* are well within the frequency estimates for osteoarthritis in contemporary populations of man in the United States (Rothschild, 1982; Engle et al., 1968). Parallel development (e.g. of placental and marsupial bovine phenotypes) appears to have been complicated by parallel susceptibility to disease. It would be of interest to compare the incidence of osteoarthritis in fossil macropods with that of contemporary kangaroos.

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